IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Heideman et al.	)	Attorney Docket No. 080743165002
Serial No.: 09/693,803	)	
Filed: October 20, 2000	)	
For: INTEGRATED OPTICAL LIGHTGUIDE DEVICE	)	
Examiner: Kang, Juliana	)	
Group Art Unit: 2874	)	
Confirmation No.: 8677	)	

AMENDMENTS TO THE DRAWINGS

Please amend FIG. 1 by dividing the figure into new FIGS. 1 and 2 and delete all numerals. Replace the numerals with a new set of numerals all as shown in the attached revised figures.

Please amend old FIG. 2 by re-labeling it as FIG. 3 and by substituting a new set of numerals as shown in the attached revised figure.

Please amend old FIG. 3 by dividing the figure into new FIGS. 4 and 5 and replacing all numerals with the new set of numerals as shown in the attached revised figures.

Please amend old FIG. 4 by dividing the figure into new FIGS. 6, 7 and 8 and replacing all numerals with a new set of numerals as shown in the attached amended figures.

Please amend old FIG. 5 by re-labeling it as FIG. 9 and replacing the numerals with a new set of numerals as shown in the attached revised figure.

Please amend old FIG. 6 by dividing the figure into new FIGS. 10 and 11 and replace the existing numerals with a new set of numerals as shown in the attached amended figures.

Please amend old FIG. 7 by dividing the figure into new FIGS. 12 and 13 and replace the numerals with a new set as shown in the attached revised figures.

Please amend old FIGS. 8A, B, C by replacing them with a new FIG. 14 which is an isometric view rather than the original plan and elevation views and replace the original numerals with a new set of numerals as shown in the amended figure.

Please amend old FIGS. 9A and B by re-labeling them FIGS. 15 and 16 which are isometric views and replace the original numerals with a set of numerals shown in the amended figures.

Please amend old FIGS. 10A, B and C by replacing them with new FIG. 17. FIG. 17 is an isometric view to replace the plan and elevation views originally shown. Please also substitute a new set of numerals for the original set as shown in the attached amended figure.

Please add new FIG. 18 which is a graphic illustration of paragraph 0034 of the specification and of original claim 8.

INTEGRATED OPTICAL LIGHTGUIDE DEVICE

BACKGROUND OF THE INVENTION

Cross Reference To Related Applications

[0001] This application claims priority and is a continuation of International Application No. PCT/NL99/00222, filed April 16, 1999, which claims priority of Netherlands Patent Application No. 1008934, filed April 20, 1998.

Statement Regarding Federally Sponsored Research

[0002] Not applicable.

Field of the Invention

[0003] The invention relates to ~~an~~ integrated optical lightguide devices ~~device~~ and more particularly to optical waveguide sensors, modulators and spectrophotometers ~~comprising a light-transmitting layer and inclusion layers and being provided with an activable element~~.

Description of the Related Art

[0004] Integrated optical sensors are ~~A device of this kind is~~ known from an ~~the~~ article entitled "Fabrication and Packaging~~packaging~~ of Integrated Chemico-Optical Sensors ~~integrated chemico-optical sensors~~" by R.G. Heideman et al., published in *Sensors and Actuators*, volume B 35-36, 1996, pp. 234-240. Besides sensors and actuators in a general sense, the ~~said~~ article describes in particular a Mach-Zehnder interferometer including ~~comprising~~ a deposited ~~sensor~~ film, which is ~~for example~~ sensitive to air humidity. The ~~Said~~ article furthermore describes an

embodiment wherein an optical fiber ~~fibre~~ for light supply is integrated in the Mach-Zehnder sensor.

[0005] Generally, such a device is much too complicated for practical applications and also ~~thus~~ relatively costly, and in some cases it is sensitive to interfering parameters~~interference signals~~ or to small deviations between intended and realised local refractive index profiles.

[0006] The operation of known integrated optical sensors and actuators, such as the Mach-Zehnder interferometer, is usually based on a phase change of the light being used, ~~which is~~ induced by ~~the activating~~a controlling parameter (actuator) or a parameter to be measured (sensor). ~~quantity, which~~ This imposes restrictions as to~~regards~~ the type of light sources to be used ~~for that purpose~~. For the lightguide structures to be used this means ~~furthermore~~that ~~any~~ transitions to and from elements in the optical structure~~, among which also the transitions to and from the activable element which takes care of the intended actuator or sensor operation,~~ will have to be provided very gradually in the direction of ~~the~~ light propagation, resulting in~~as a result of which they will be~~ relatively long structures.

[0007] U.S. Patent Number 4,913,519 (corresponding to WO 8908273) also discloses an optical sensor structure wherein an optical fiber is covered with a periodic, interrupted cladding layer in such a manner that a parameter to be detected, a change from water to ice and from ice to water, causes the sensor operation to switch between an "off" condition where there is no light transmission when water is present and an "on" condition where light is transmitted when the water changes to ice. This patent illustrates the use of segments of identical length which are periodically spaced, but is otherwise very limited in application.

BRIEF SUMMARY OF THE INVENTION

[0008] The object of the invention is to obviate the above drawbacks. ~~, and in order to accomplish that objective~~The object is accomplished by an integrated optical lightguide device of the kind mentioned in the introduction in which a material is incorporated where the value of the refractive index depends on an external physical or chemical parameter. ~~is characterized in that said activable element~~The device is divided in a light propagation direction ~~of the lightguide~~ into ~~several, mutually separated individual~~a series of several types of segments each having different specific refractive index distributions~~profiles and/or different material profiles~~. The segments may take a variety of different shapes, sizes and spacings and may be in the form of sensor material filled recesses or altered cladding regions. The~~Said~~ segmentation may relate to a slab-type lightguide as well as to a channel-type lightguide. This optical lightguide device can, for example, be used as a sensor, as an intensity modulator and as a spectrophotometer.

[0009] The invention is essentially based on the knowledge ~~insight~~ that when a guided light beam passes through a boundary surface between two light-transmitting segments ~~parts~~ having ~~mutually~~ different refractive index profiles, the portion of the light that is transmitted by the ~~said~~ boundary surface as a guided beam ~~guided~~ within the light-transmitting structure and the light that is radiated is determined by the difference in the refractive indices ~~index~~ of the ~~profile between said~~ two light-transmitting parts and of differences in guided mode field profiles. ~~Especially the degree of light reflection resulting from said difference in the refractive index profiles and the degree to which the light exits the lightguide in the form of radiating modes as a result of a mismatch of the guided mode field profiles of the light being used on either side of said boundary surface are the determining factors in this case.~~ When a change in the value of an external physical or chemical parameter ~~quantity~~ directly or indirectly causes the refractive

indices ~~index profiles of the lightguides~~ on either side of the boundary surface ~~change~~ to change ~~to different degrees~~, the consequent changes in the effective refractive indices and the mode field profiles will produce a change in the amounts of light reflected on the boundary surface, in the light beams transmitted by the boundary surface as guided modes, as well as in the light ~~beams~~ emitted on the boundary surface in the form of radiating modes. Thus, the ~~(~~change in the~~)~~ amount of light transmitted as a guided light beam is determined by and constitutes a measure of the ~~(~~change in the~~)~~ external parameter~~quantity~~. Instead of the light transmission, ~~also~~ the amount or the distribution of the light converted into radiating modes and/or the amount of reflected light may function as a measure of the ~~(~~change in the~~)~~ external parameter~~quantity~~. Essential in this respect is the fact that the intended effect does not depend on the degree of coherence of the light being used, and consequently it is ~~also~~possible to use inexpensive, non-coherent light sources, such as light emitting diodes (LEDs), fluorescent lamps, halogen lamps, Xenon lamps, etc., as a light source instead of ~~besides~~ relatively expensive gas lasers, solid matter lasers and/or laser diodes.

[0010] Although the changes may be relatively small in the case of a single transition, the use of many transitions succeeding each another in the direction of ~~the~~ light propagation may produce significant effects. Essential in this respect is that ~~the degree of~~ repetition of the ~~said~~ transitions, and thus of the segments of parameter sensitive material or sensor material~~the activable element~~, does not need to be periodical~~,~~ because the operating principle is not based on phase information of the light being used, although ~~it is also quite possible for~~ a device according to the invention may ~~to~~ use periodically repeated segments.

[0011] ~~In one preferred embodiment, the device comprises, in succession,~~ The lightguide described here is formed of layers, including a carrier, a first inclusion layer, a light transmitting

layer and a second inclusion layer. If suitable specifications are used, in particular with regard to ~~as regards~~ the refractive index, the ~~said~~ carrier can also function as a first inclusion layer.

[0012] The forming of such layer structures can be done with well-defined, controllable techniques which are well known to those skilled in the art ~~per se~~. Thus, layers having a precisely defined thickness and composition can be formed ~~realised~~ by means of evaporation, sputtering, indiffusion ~~vaporisation~~, CVD techniques and the like. In one preferred embodiment, channel-type lightguides are formed in the ~~said~~ layer structures by means of ~~e.g.~~ photolithographic ~~techniques~~ and etching techniques, for example. In a device according to the invention, the parameter sensitive material ~~activable element~~ is formed ~~built up~~ of segments of at least two different types ~~kinds~~. Segments belong to the same type if they have the same ~~exhibit similar~~ refractive index profiles and ~~material~~ mode field profiles in a plane perpendicularly to the propagation direction of the lightguide. Accordingly, segments of the same type ~~exhibit the same degree of activability, that is, the effective refractive indices and the mode field profiles of the guided modes in segments of the same type~~ are influenced to the same degree by the parameter ~~quantity~~ to which the segments are ~~activable segment is~~ sensitive. The dimensions of such segments, measured in the propagation direction of the lightguide, range between approximately one ~~approx. 1~~ micron and a few dozen microns ~~micron~~.

[0013] Sensitive ~~Activable~~ segments contain a ~~an activable~~ material~~, which in this case means a material~~ whose refractive index ~~value~~ depends on the quantity of an external parameter, also known as a measurand ~~quantity~~. These materials include for example chemo ~~chemico~~-optical transduction materials~~,~~ whose refractive indices depend ~~index depends~~ on the concentration of a specific substance or of several substances. Besides the above materials, ~~also~~ thermo-optical, electro-optical, magneto-optical, opto-optical and elasto-optical materials can be used, which

material can be activated by, respectively, a temperature change, an electric field, a magnetic field, a change in light intensity and a mechanical stress~~ or stretch~~.

[0014] In another ~~one~~ preferred embodiment, ~~said activable element consists of a succession of~~ two types of aligned segments, where ~~wherein~~ each type exhibits a different degree of sensitivity to a specific parameter~~ activability~~.

[0015] In yet another preferred embodiment, one of the aligned two segments has zero sensitivity to the parameter~~the activable element consists of a succession of two types of segments, with the activability of one of said types being zero~~. In this case, the sensitive ~~activable~~ segments are monotype ~~activable~~ segments~~,~~ which are ~~mutually~~ separated by segments ~~which are~~ insensitive to the measurand~~quantity~~, and these are called ~~the so-called~~ bridge segments~~ portions~~.

[0016] ~~In another preferred embodiment, segments exhibiting different degrees of activability are~~ Parameter sensitive segments may be formed by:

- the local removal of portions of a ~~(part of) the~~ light sealing layer covering the light-transmitting layer, and optionally also removing at the same time portions of the underlying light-transmitting layer, or~~ whether or not simultaneously with parts of the underlying light-transmitting layer, or~~

- the local removal of the light-transmitting layer, or

- ~~or~~ the local application of a new layer~~ one of the component layers~~.

[0017] ~~More in particular, the~~ If there is removal, spaces thus formed are filled partially or entirely with a material exhibiting a different degree of sensitivity ~~activability~~ than the removed

material, or if there is ~~the~~ locally applied new material, it exhibits a different degree of sensitivity than the material covered.

[0018] ~~In another embodiment, said~~ The spaces may be ~~are~~ filled entirely or partially with a liquid or a gas~~,~~ as the sensitive material whose composition determines the refractive index ~~profile~~ of the segments containing the ~~said~~ liquid or the ~~said~~ gas. This structure ~~embodiment~~ is especially suitable for measuring the composition of a liquid or a gas mixture or for determining the concentration of ~~the~~ substances ~~which are~~ dissolved in the ~~said~~ liquid.

[0019] The local removal of ~~the~~ inclusion material can be done ~~realised~~ mechanically, such as ~~e.g.~~ by stamping or ~~in the second inclusion layer, and in particular also~~ by ~~means of~~ photolithography and etching ~~after the application of the second inclusion layer~~. Thus, a large number, for example hundreds, of aligned ~~successive~~ segments can be formed ~~realised~~ on a relatively short waveguide, such as ~~for example~~ a waveguide having a length dimension of one mm to a few mm. The above also applies if there are more than two ~~mutually~~ different types of segments.

[0020] As mentioned, such ~~Such~~ segments may have unequal dimensions and/or be spaced unequal distances apart. The positioning and dimensions of different types of segments can be selected at random, ~~therefore,~~ so that an extra degree of freedom is obtained.

~~[0021] It should be noted that WO 8908273 discloses an optical sensor structure wherein an optical fibre core or another lightguide is covered with an interrupted cladding layer, in such a manner that a transition between water and ice in the cladding causes the sensor operation to switch from wave guidance, that is, functioning as a light transmitting element, to nonguidance,~~

~~or vice versa. Thus it is possible to detect the presence or absence of a chemical substance, or in this case water or ice, by means of such a transition.~~

~~[0022]~~ [0021] Another preferred embodiment of the invention is formed ~~built up~~ of two types of segments, one of which is parameter sensitive~~activable~~, while ~~whilst~~ the other is not. ~~The two types of segments differ from each other as regards the nature of the inclusion material or the light-transmitting material. In one type of segment said material is activable and in the other it is not; the latter material is the so-called bridge material.~~ In this embodiment the refractive indices of the bridge material and the sensor material are related ~~geared~~ to each other with a view to achieving ~~an~~ optimum sensitivity ~~of the activable element~~ for variations ~~variation~~ of the parameter ~~activating quantity~~ within a particular range. The relationship~~Said gearing to each other~~ implies that a value of the parameter ~~activating quantity~~ exists within the ~~said~~ particular range~~,~~ with a ~~the~~ corresponding value of the refractive index of the ~~activable~~sensor material being equal to that of the bridge ~~inclusion~~ material or the light-transmitting material. This ~~point~~ is called the working point of the sensor material ~~activable element~~.

~~[0023]~~ [0022] The bridge material for a lightguide used to measure ~~an activable element by means of which the~~ relative humidity ~~can be measured~~ may include ~~for example consist of~~ SiON having a refractive index of ~~for example~~ 1.50, and ~~of~~ a material ~~which is~~ sensitive to air humidity may be~~, for example~~ gelatin~~,~~ having a refractive index range of 1.53 - 1.47 in the air humidity range of 0 - 100%. By increasing the number of segments it is possible, using the same materials, to obtain excellent ~~an extremely steep~~ sensitivity to air humidity~~, to be defined as a peak-like sensitivity,~~ over a smaller part of the refractive index range to be measured around the air humidity value which corresponds with a gelatin refractive index of 1.50. ~~By increasing the number of segments, said peak effect can even be enhanced.~~ This is sometimes called a peak

response and it may ~~Such a peak-like response can~~ be used as a switching pulse in an electronic circuit designed ~~composed~~ for that purpose. The selection of a refractive index of 1.53 for the bridge material makes it possible to measure refractive index values in the range of 1.52 - 1.53 with great precision. This range corresponds with an air humidity between of 90 - 100%. ~~This method, wherein the number of segments is selected so that a change of a quantity to be measured will result in a peak-like response, can also be used for other sensor applications. Such a sensor is in particular~~ A chemical sensor giving peak responses may be useful for measuring the composition of a liquid or a gas mixture~~, for example,~~ for the purpose of checking chemical processes, or for use in alarm systems to signal the exceeding of humidity limits, or to signal the occurrence of undesirable ~~inadmissible~~ air or water pollution. ~~The selection of a refractive index of 1.53 for the bridge material makes it possible to measure refractive index values in the range of 1.52 – 1.53 with great sensitivity, for example. This range corresponds with an air humidity range of 90 – 100%.~~

~~[0024]~~ [0023] In another preferred embodiment, ~~the activable element consists of a light-transmitting material, for example~~ a ridge-type light-transmitting channel~~, which possesses~~ having a constant cross-sectional dimension, includes in ~~and~~ the inclusion layer alternately parameter sensitive segments ~~consists of an activable~~ and generally non-sensitive segments ~~an at least substantially non-activable material~~ over the entire width of the mode field profile ~~which relevant for the light transmission in the direction of propagation of the light, by which the segments of the activable element are defined~~.

~~[0025]~~ [0024] In still another preferred embodiment, ~~the activable material consists of~~ a ridge-type light-transmitting channel~~, for example a ridge-type light-transmitting channel, wherein the~~ has two types of segments of identical material but differing~~differ~~ from each other in

~~as regards the~~ channel widths ~~width~~. Even though the segments are of different widths, they are related in that the mode field profiles of each is substantially identical for a relevant value of a parameter quantity. Furthermore, when ~~The two widths are geared to each other in such a manner that when only one type of activable inclusion material is used as a cladding material, the mode field profiles in both types of segments are at least substantially identical for a relevant value of the activating quantity. When~~ the value of the measurand ~~activating quantity~~ changes, the mode field profiles of the two segments will also change but in an ~~the~~ opposite sense, that is, the mode field profile of one ~~type~~ of the two segments ~~segment~~ will become wider, and the mode field profile of the other ~~type~~ of the two segments ~~segment, on the other hand,~~ will become narrower. Thus, more light will be converted to radiating modes and be reflected at one segment than at the other and less light will be transmitted as guided modes while the opposite is true at the other segment.~~, resulting in a mode field profile mismatch as described before, as a result of which the amount of light transmitted as guided modes on a boundary surface between segments of different types will change, as will the amount of light converted into radiating modes on said boundary surface and the amount of reflected light.~~

~~[0026]~~ [0025] In another preferred embodiment of a sensor, a reference channel~~, for example for temperature correction, is incorporated in the device in addition to an activable element of a channel-type lightguide. By using the reference channel as a dummy,~~ which will not come into contact with the parameter ~~medium to be measured, therefore, a reference signal is obtained, which makes it possible to carry~~ carries out absolute measurements.

~~[0027]~~ [0026] ~~In another preferred embodiment, the activable~~ Parameter sensitive segments may be ~~are~~ formed by local physical and/or chemical treatment of the inclusion layer material and/or of the light-transmitting material. ~~Thus, an activable inclusion~~ Inclusion layer material

can be deactivated partially or entirely by means of electromagnetic radiation, for example by UV irradiation, where ~~as a result of which~~ the irradiated segments ~~have~~ become non-sensitive or less sensitive ~~non-activable or less activable,~~ as compared ~~contrary~~ to the non-irradiated segments, or the irradiated segments react differently, at least in relation to their ~~dependence on the~~ refractive index ~~thereof,~~ to such a degree that a usable signal change is ~~can be~~ obtained.

~~[0028]~~ [0027] In another preferred embodiment, ~~the light-transmitting channel is defined as~~ a strip-loaded ~~(provided with a strip)~~ type of light transmitting ~~light-transmitting~~ channel is formed ~~within the activable element~~ by applying to the light transmitting ~~said light-transmitting~~ layer a layer of parameter sensitive ~~an activable~~ material having a constant thickness of, for example, 1 - 200 nm, and subsequently removing the parameter sensitive ~~said~~ material~~, using suitable techniques,~~ outside the region ~~area~~ to be defined as a channel. Alternatively, the strip may ~~strip-loaded type light-transmitting channel can~~ be formed by ~~applying the activable inclusion layer only at the location of the channel area by means of~~ a local chemical or physical treatment either of the region ~~area~~ to be defined as the channel ~~area~~ or of a region ~~the area~~ that does not form any part of the channel~~-area~~. ~~Subsequently, the activable segments and the segments that are not activable or less activable are defined by local treatment of the inclusion material.~~ As a result of this local treatment, the refractive index will hardly vary, if at all, at least at a particular wavelength, ~~as a result of which~~ and the refractive index profiles of the two types of segments will be substantially or completely identical at a zero value of the parameter, resulting in ~~activating quantity, and~~ a maximum transmission of light intensity~~the guided mode will be obtained~~.

~~[0029]~~ [0028] ~~In another preferred embodiment of such a channel-type activable element, for example a strip-loaded or ridge-type element, the activable~~ The parameter sensitive inclusion

material may be chemo ~~is a chemico~~ optical material~~,~~ which can be used for concentration determination in biological tests, and in particular, pregnancy tests. ~~Activable and less activable~~ Sensitive and less sensitive segments may be formed ~~are defined by local treatment in this activable material, for example~~ by local deactivation by means of ~~local~~ electromagnetic radiation~~, for example~~ with UV light.

~~[0030]~~ [0029] ~~In another preferred embodiment, the light-transmitting layer is homogeneously coated with an activable layer~~ The light transmitting layer may be formed by homogeneously coating a parameter sensitive material having a thickness of ~~e.g.~~ approximately 1 - 200 nm. This sensitive ~~activable~~ layer is then subjected to local chemical or physical treatment, as a result of which the degree of sensitivity ~~activation~~ as well as the refractive index will change. ~~The change in the refractive index of the activable layer is used for the definition of a strip-loaded type of segmented light transmission channel.~~

~~[0031]~~ [0030] Since the differences in the refractive index profiles ~~indices~~ of the various types of segments will usually be small in the presence of the measurand~~activating chemical entities~~, a relatively large number of segments will be required. These may be formed using ~~In order to realise this, it is possible to use~~ holographic and Moire lighting techniques and pattern forming ~~in addition to using patterning by means of~~ masks. ~~Although the periodicity of the structures formed thereby is not required for most uses, this method is~~ These methods are especially suitable for those lightguides ~~devices according to the invention~~ where ~~wherein~~ a fine structure ~~(length dimensions of the segments of for example less than 3 micron)~~ is desired (having segment length dimensions of less than 3 microns, for example), or where ~~wherein~~ specific requirements apply, for example, as regards the gradients in the transitions between sensitive and non-sensitive ~~various materials of activable and non-activable~~ segments.

~~[0032]~~ [0031] In another ~~one~~ preferred embodiment, sensitive ~~the activable~~ segments contain an electro-optical, thermo-optical, magneto-optical, opto-optical or elasto-optical material, with ~~as a result of which~~ the light transmission of the lightguide device to ~~can~~ be controlled by varying~~variation of~~, respectively, an ~~the supplied~~ electrical field, ~~the~~ temperature, a ~~the~~ magnetic field, light intensity or a ~~the~~ mechanical stress or pressure in the material, thus forming an intensity modulator. In an alternative embodiment of the ~~said~~ modulator, one of the layers forming the lightguide includes ~~consists entirely of an activable~~ sensor material that is effected in segments. For example, an electric field or heat may be applied by irregularly spaced electrodes.~~, but the lightguide is only activated locally. Local activation of for example electro-optical and thermo-optical actuators, for example, can take place by applying an electrical tension to locally provided electrodes.~~ The regions ~~parts provided with~~adjacent the electrodes will form the parameter sensitive ~~activable~~ segments.~~in that case. In the case of excitation by means of said electrical tension, an electrical field or heating is effected at the location of said activable segments.~~

~~[0033]~~ [0032] ZnO is a suitable material to be effected by an electric field. Electrodes may also be used to pass a current and thereby heating material where both techniques allow variations in the refractive index profile of the material. ~~In one preferred embodiment, the activators make use of electrodes which have been provided on the activable segments by means of vaporisation, for example, or a similar technique. An electrical field can be applied by means of such electrodes over a suitable medium whose refractive index can be varied with an electrical field, such as ZnO, as a result of which the guided light beam can be controlled via refractive index profile variation, which in this case means that it is possible to manipulate the intensity thereof. The electrode on the activable element can also be use as a current supply wire for~~

~~generating heat, as a result of which the reflective index profile will change when suitable materials are used in the activable element, which makes it possible to control the guided light beam locally by means of refractive index profile variation. Besides the aforesaid materials and physical phenomena, also other~~ Other materials and physical phenomena may be used for light intensity modulators ~~if it is possible to generate a~~ through refractive index variation ~~therein~~ by ~~means of~~ external activators, such as magnetic fields, pressure, deflection ~~(whether or not by means of electrodes provided on the activable segments) and/or by means of external influencing, electrically, magnetically, temperature, movement, force, distance, deflection, tension, pressure~~ and the like.

~~[0034]~~ [0033] ~~In another preferred embodiment, said activable material consists of a light-transmission channel, for example a ridge-type light-transmission channel, wherein the two types, of segments differ from each other as regards the channel width. Said two widths are geared to each other in such a manner that the mode field profiles in the two types of segments are at least substantially identical for a relevant value of the activating quantity. In this embodiment, the second inclusion layer and/or the light-transmitting layer are made up of only one activable material, wherein~~ Where a light transmitting channel is formed by segments of the same material but differing widths, a non-patterned metal film may function ~~functions~~ as an electrode. When the value of the ~~activating~~ parameter ~~quantity~~ changes, the mode field profiles will change in an ~~the~~ opposite sense, that is, the mode field profile of one ~~type~~ of the two segments~~segment~~ will become wider, and the mode field profile of the other ~~type~~ of the two segments ~~segment, on the other hand,~~ will become narrower, resulting in a mode field profile mismatch as described above ~~before~~, and as a result ~~of which~~ the amount of light transmitted as guided modes on a boundary surface between segments ~~of different types~~ will change, as will the

amount of light converted into radiating modes ~~on said boundary surface~~ and the amount of light reflected ~~light~~.

~~[0035]~~ [0034] In another preferred embodiment, ~~the activable element consists of~~ two types of-segments~~, which can be activated~~ are effected by different parameters~~quantities~~. For example, ~~Thus,~~ one group of segments ~~type of segment~~ may contain a chemo ~~chemico~~-optical material, and the other group of segments ~~type of segment~~ may contain an electro-optical material~~, for example~~. The ~~Said types of segments have at least substantially the same~~ cross-sectional dimensions of the two different types of segments may be the same, ~~dimension,~~ while ~~whilst also~~ the values of their ~~the respective~~ refractive indices ~~are geared to each other in such a manner that the refractive index profiles of the two segments~~ are identical for a set of relevant values for each of the different ~~activating~~ parameters~~quantities~~. In this state, ~~At this point, to be called~~ the working point of the sensor, the transmission factor of the segmented lightguide is at a maximum, ~~activable element ix maximally~~ T_{max}. When there is ~~In the case of~~ a refractive index change in one segment induced by a parameter ~~quantity~~ A, the other ~~type of~~ segment may ~~can~~ be forced to undergo an identical refractive index change by altering parameter ~~means of a properly controllable value of activating~~ B, so as to have ~~wherein the identicalness criterion is that~~ the transmission factor ~~be~~ equal to T_{max}. Thus, the value of ~~the~~ measurand ~~quantity~~ A may ~~to be measured can~~ be correlated ~~unequivocally~~ with the known value of parameter ~~quantity~~ B. This process can be automated by means of a feedback loop.

~~[0036]~~ [0035] In another preferred embodiment, the refractive index ~~profile and/or the material profile~~ at the location of the non-sensitive ~~non-activable~~ segments may ~~can~~ be optimized for wavelength ~~sensitive~~ measurements, such that the amount of light being transported through the lightguide ~~device in guided modes~~ is wavelength-dependent, as is the intensity distribution of

the light emitted by the segments. Thus the ~~it is possible to realise a~~ lightguide acts as ~~device in the form of~~ a spectrophotometer ~~spectrometer~~. In such a spectrophotometer ~~spectrometer~~, an array of photosensitive segments~~, for example~~ in the form of a photodiode array or a linear CCD chip, is used ~~added~~ for measuring laterally emitted light~~, as a result of which a wavelength-sensitive measurement is realised by means of a location-dependent measurement, viz. in the propagation direction of the lightguide. To that end, the~~ The photodiode array contains a number of photodiodes in the propagation direction of the lightguide, and the CCD chip contains a number of elements by which the exiting light can be measured as a function of the propagation direction, thus making it possible to determine a diffusion distribution. The light detector may extend along the entire lightguide ~~waveguide~~ length or may overlap only part of it ~~thereof~~. A light detector array may be provided on one side or on both sides of the lightguide. Both the number of photodiodes of the array and the number of ~~activable~~ parameter sensitive segments contribute to diffusion ~~the wavelength dissolving~~ capacity ~~in the diffusion direction~~.

~~[0037]~~ [0036] In another preferred embodiment, parameter sensitive ~~activable~~ segments are used which do not impeded light when~~, and that exclusively in transmission. No disturbance occurs~~ in a quiescent condition ~~thereby~~. ~~The electrodes are not excited in that case. As soon~~ When electrical excitation takes ~~does take~~ place, ~~a disturbance will occur at each segment, due to~~ there is a change in the refractive index ~~profile~~. This ~~Said~~ change is not ~~a~~ permanent. ~~change, therefore. Each situation, that is, each~~ Each excitation voltage or current is associated with a particular refractive index ~~value of each refractive index profile disturbance~~. The ~~Said~~ resulting refractive index profile change ~~disturbance~~ is different ~~now perceived differently~~ for each wavelength~~,~~ because the waveguide exhibits wavelength dispersion. Each wavelength that is present will pass through the system to a different degree and thus have a different transmission

value~~, therefore~~. Hence, the ~~The~~ amount of light that passes through the lightguide becomes ~~has become~~ wavelength-dependent~~, therefore~~.

~~[0038]~~ [0037] In this situation, ~~that is,~~ upon ~~activation by means of an~~ excitation ~~voltage or current, the~~ total light transmission is measured. Then the ~~said~~ excitation voltage or current is increased~~,~~ and ~~the total intensity of~~ the light transmission ~~light~~ is measured anew. This is repeated several times in succession. ~~, that is, electrode~~ Electrode voltages or currents having different values are used each time, and with each of the new ~~said~~ values a measurement is made of the amount of light exiting ~~exits~~ from the entire system, where ~~whereby~~ it is not known ~~at that moment~~ what wavelengths the ~~said~~ light contains. On the basis of the amount of light determined by transmission measurements, ~~measurement~~ the spectral content of the presented light can be determined ~~afterwards~~, after ~~such~~ a complete series of measurements have ~~has~~ been made, using arithmetic algorithms. Subsequently, the excitation ~~activator~~ is turned off ~~again~~ and all of the light will pass through the lightguide unimpeded ~~total system, so that it will be freely available again~~.

~~[0039]~~ [0038] ~~Hereafter a few examples of a device according to the invention will be described in more detail with reference to the drawing. In the drawing:~~ A more complete understanding of the present invention and other objects, advantages and features thereof will be gained from a consideration of the following description of preferred embodiments read in conjunction with the accompanying drawing provided herein. The preferred embodiments represent examples of the invention which are described here in compliance with Title 35 U.S.C. section 112 (first paragraph), but the invention itself is defined by the attached claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

~~[0040]~~ [0039] FIGURE 1 is a diagrammatic longitudinal sectional elevation view of a segmented waveguide sensor or modulation.~~Figure 1 shows a principle sketch of a device according to the invention;~~

~~[0041]~~ [0040] FIGURE 2 is an enlargement taken within circle 2-2 of FIG. 1.

~~[0042]~~ [0041] FIGURE 3 is a diagrammatic longitudinal sectional elevation view of a segmented waveguide sensor or modulator ~~Figure 2 shows an example of such a device, which is fitted~~ with a light supply, an optical input fiber and an optical output fiber. ~~discharge means;~~

~~[0043]~~ [0042] FIGURES 4 and 5 are diagrammatic top views of lightguides illustrating the use of reference channels. ~~Figure 3 shows embodiments of a device comprising a reference channel;~~

~~[0044]~~ [0043] FIGURES 6, 7 and 8 are enlarged views similar to FIG. 2 but illustrating ~~Figure 4 shows~~ different segment geometries.~~embodiments of activable segments of such a device;~~

~~[0045]~~ [0044] FIGURE 9 is a diagrammatic longitudinal plan view of a lightguide sensor with ~~Figure 5 shows an example of a device comprising~~ an integrated light source and detector and illustrating the use of electrodes.~~;~~

~~[0046]~~ [0045] FIGURE 10 is a diagrammatic longitudinal sectional view of a lightguide usable as a moduator or a spectrophotometer for determining the wavelength of monochromatic light.~~Figure 6 shows examples of a device in the form of, respectively, a controllable intensity modulator and a spectrometer;~~

~~[0047]~~ [0046] FIGURE 11 is a diagrammatic longitudinal plan view of another lightguide that may be used as a modulator or a spectrophotometer.

~~[0048]~~ [0047] FIGURE 12 is a diagrammatic longitudinal sectional elevation view of another spectrophotometer.~~Figure 7 shows an example of a device which can be used as a spectrometer;~~

~~[0049]~~ [0048] FIGURE 13 is an enlargment taken within circle 13-13 of FIG. 12;

~~[0050]~~ [0049] FIGURE 14 is a diagrammatic isometric view of a lightguide sensor with segments of different widths.~~Figure 8 shows an example of a device wherein two kinds of activable segments operating on the different widths principle can be used;~~

~~[0051]~~ [0050] FIGURE 15 is a diagrammatic isometric view ~~Figure 9 is a general representation~~ of a ridge-type channel-type lightguide in which segmentation is achieved by locally desensitizing a sensitive layer.~~and a strip-loaded channel-type lightguide; and~~

~~[0052]~~ [0051] FIGURE 16 is a diagrammatic isometric view of a strip-loaded channel lightguide, in which both the channel and the segmentation have been defined by locally desensitizing a sensitive layer.

~~[0053]~~ [0052] FIGURE 17 ~~Figure 10~~ is a diagrammatic isometric view ~~representation~~ of a segmented strip-loaded channel guide, of which segmentation has been achieved by locally desensitizing the sensitive strip material ~~lightguide~~.

~~[0054]~~ [0053] FIGURE 18 is a diagrammatic longitudinal sectional elevation view of a lightguide with feedback capabilities.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

~~[0055]~~ [0054] While the present invention is open to various modifications and alternative constructions, the preferred embodiments shown in the various figures of the drawing will be described herein in detail. It is understood, however, that there is no intention to limit the invention to the particular embodiments, forms or examples disclosed. On the contrary, the intention is to cover all modifications, equivalent structures and methods, and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims, pursuant to Title 35 U.S.C. section 112 (second paragraph).

~~[0056]~~ [0055] A light guide 10 ~~device~~ according to the invention is ~~as~~ depicted in FIGURES 1 and 2 and includes~~Figure 1 comprises~~ a carrier 12, such as a silicon wafer~~1~~, a first inclusion, buffer or substrate layer 14~~2~~, a light-transmitting or core layer 16~~4~~ and a second inclusion or cladding layer 18~~6~~. ~~Present in inclusion layer 6 are activable~~Parameter sensitive segments are formed~~, in this case in the form of recesses 8~~ in the cladding ~~inclusion~~ layer 18 by creating recesses 20 which may extend into the core ~~light transmitting~~ layer 16 also~~for different uses~~. When the lightguide ~~device~~ is used as a sensor, for example for air humidity measurements, or measurements of the composition of gases or liquids ~~and the like~~, the ~~said~~ recesses are filled with a medium or sensor material 22 ~~17~~ having a refractive index which is sensitive to the parameter ~~quantity~~ to be measured. ~~Thus it is possible to use~~ Examples are gelatin~~,~~ and polyimide, ~~etc.~~, for air humidity measurements. Between the recesses 20 is cladding material 24, called a bridge segment and each boundary between two adjacent segments is called a transition 26.~~In order to realise a sensitive measurement, it is possible to gear refractive index profiles optimally to each other at the location of bridge material 15 and sensor material 17. It is also possible to measure with direct refractive index variations for various measurements, that is, the medium~~ The

parameter to be measured, also known as the measurand, for example, a gas or a liquid, fills the recesses ~~during the measurement~~ and determines the refractive index of the segment ~~thereof~~, which refractive index is a function of ~~determines~~ the quantity of the measurand ~~to be measured~~, for example, the concentration of a particular substance in the recess ~~therein~~, or the ~~a particular~~ proportion in a mixture of various liquids in the recess. ~~An encircled portion 5 of the lightguide structure is shown on a larger scale in the same figure.~~

~~[0057]~~ [0056] Referring now to FIG. 2, there is shown a graphic illustration ~~The drawing indicates in one of the recesses 8 a measure~~ of ~~the~~ a light intensity distribution 30 in the lightguide, as well as a light reflection distribution 32 at the transition 26 ~~intensity 10 entering in guided mode for a transition 12, for an intensity 14 reflected at said transition~~ and the remaining light intensity distribution 34 ~~of the intensity 16~~ being transmitted in guided mode. Arrows 36 ~~18~~ indicate that part of the incoming light beam is converted into radiating modes, which will ~~(eventually)~~ exit the lightguide laterally. The light intensity ~~It is possible to measure the light exiting~~ in a propagation direction 38 may be measured as may ~~20 of the lightguide device and/or~~ the light being emitted laterally.

~~[0058]~~ [0057] It is to be ~~furthermore~~ noted that the recesses 20 are ~~do~~ not ~~need to be~~ identical lengthwise nor ~~or be~~ evenly distributed. Nor is the operation of the lightguide ~~device~~ affected if one or more of the recesses continue more deeply ~~deeper~~ or less deeply into the light-transmitting or core layer or whether ~~locally enclose~~ the core ~~said~~ layer is covered completely. It is also to be noted that sensitivity may be increased by relating the refractive indices of the parameter sensitive segments and the bridge segments.

~~[0059]~~ [0058] FIG. 3 ~~Figure 2~~ shows an integrated optical channel-type lightguide device 40, with recesses 42 ~~8~~ being provided in the inclusion or cladding layer 44~~6 again, which~~ and where the recesses are filled with sensitive ~~sensor~~ material 46~~17~~. A light entry or input optical fiber 48 ~~fibre 26~~ is provided on an entry side 50~~24~~ of the lightguide and a light detection or output optical fiber 52 ~~fibre 30~~ is provided on an exit side 54 of the lightguide ~~28~~. The lightguide ~~A device~~ as described may have ~~has~~ a length of ~~e.g.~~ one centimeter ~~centimetre~~ and a width of a few millimeters~~millimetres~~, and the number of recesses it contains may range from just a few to a few hundred, depending upon ~~on~~ the application. Also, other channel structures may similarly include ~~comprise~~ a light entry optical fiber ~~fibre~~ and/or a light detection optical fiber ~~fibre~~.

~~[0060]~~ [0059] Lightguides 60, 62 ~~Devices~~ as depicted in FIGS. 4 and 5 include ~~Figure 3 comprise~~ one or more lateral channels which can be used as reference channels. This makes it possible to compensate for external influences, such as ~~the~~ ambient temperature, partially or completely during ~~the~~ measurement, and to realize ~~realise~~ absolute measurements. The lightguide 60 of FIG. 4 ~~Figure 3A~~ shows a measuring channel 64 with parameter sensitive segments 66 and a reference channel 68 ~~30~~ which does not pass any parameter sensitive ~~activable~~ segments ~~32~~ and thus ~~which~~ is not influenced by the parameter ~~medium~~ to be measured~~, therefore~~. The lightguide 62 of FIG. 5 ~~Figure 3B~~ shows an embodiment comprising a cuvette 70~~34~~, which divides the guide into a measuring cuvette 72~~36~~, with parameter senstivie segments~~which is activated~~, and a reference cuvette 74~~38~~, with reference segments unaffected by the measurand ~~which is not activated, even though it is provided with recesses for activable segments~~.

~~[0061]~~ [0060] Referring now to FIGS. 6, 7 and 8, ~~Figure 4 shows~~ various embodiments of recess geometrics ~~recesses~~ for activable parameter sensitive segments are shown. ~~according to~~

~~the invention, such as~~ These include a rectangular shaped recess 80~~shape 40~~, a conical shaped recess 82 ~~shape 42~~ and a parallelogram shaped recess 84~~shape 44~~. The variety of available ~~free selection of said~~ shapes provides additional freedom in the selection of sensors or actuators. It should be noted that ~~Especially~~ the degree of laterally emitted light can be varied as a function of ~~with~~ the geometry of the recess transitions. Furthermore, the recesses may be positioned perpendicular ~~provided perpendicularly~~ to the propagation direction of a ~~the~~ guided light beam or at an angle deviating from 90^0 thereto, or the recesses may have a different geometry than those shown. As with the FIG. 1 lightguide, each embodiment just disclosed includes a carrier layer 86, a first inclusion layer 88, a core layer 90, a cladding layer 92 and parameter sensitive material 94 in the recesses.

~~[0062]~~ [0061] It is also noted that instead of being formed by recesses, segments may also be formed by a locally deviating physical or chemical treatment of a cladding ~~an inclusion~~ layer. ~~Also in that case it is possible to provide~~ Furthermore, the above mentioned ~~indicated~~ different geometries may be formed in the cladding layer by the physical or chemical treatment so as to not require the removal of the cladding~~. This can be realised without having to remove inclusion~~ layer material~~, therefore~~.

~~[0063]~~ [0062] FIG. 9 ~~A device as depicted in Figure 5~~ shows a segmented sensor system 100 that includes ~~comprises~~ an integrated light source 102 ~~50~~, an integrated light detector 104, parameter sensitive ~~52 and open, activable~~ segments 106, ~~7~~ as well as segments 108 ~~9~~ which are changeable ~~for example provided~~ with an electrode. In this case, ~~such~~ a light source can be selected on the basis of the price, performance ~~the capacity~~ and its ability to integrate ~~the possibility of integration~~, since the sensor offers no phase information; hence, no monochromatic, coherent light source is required ~~selection of the light source is not bound by~~

~~specific emission bandwidth requirements to be made thereof, as long as no phase information of the guided light beam is measured~~. For ~~Quite advantageous is for~~ example, ~~the use of~~ an LED or a VCSEL light source may be advantageously used. The two kinds of segments 106, 108 ~~7 and 9~~ may be arranged to provide ~~also be positioned in adjoining relationship, to which end the depicted device provides~~ a feedback possibility. ~~Thus it is possible to realise mutual influencing of the signals occurring on both segments, as As a result of which it is possible to carry out the aforesaid maximum transmission method.~~As explained earlier and again below, a feedback arrangement where light transmission is maintained at a maximum level may be used to determine a desired measurand.

~~[0064]~~ [0063] Two embodiments of ~~an~~ integrated optical lightguides ~~lightguide device~~ for use as an intensity modulators ~~modulator~~ are shown in FIGS. 10 and 11~~Figures 6a (in side view) and Figure 6B (in plan view)~~. The lightguide 110 ~~External control of the device as~~ shown in FIG. 10 ~~Figure 6a~~ includes ~~is provided by activable segments 62, which comprise~~ a lower electrode 112, ~~61, which is required for electro-optical activation, and~~ upper electrodes 114 and parameter sensitive material 116 ~~60~~. The ~~refractive index of the~~ sensor material ~~present~~ under the upper electrodes 114 form segments 118 ~~is~~ whose refractive index is varied by means of electric control signals on the ~~said~~ electrodes. As ~~, as~~ a result of the signals ~~which~~ the ~~prevailing~~ refractive index ~~profile~~ at the segment locations are ~~that location is~~ changed and the intensity of the transmissed light ~~degree of light transmission~~ is controlled. ~~It is noted that the actuator as~~ The lightguide 120 shown in FIG. 11 ~~Figure 6b~~ may also be configured so that the parameter sensitive ~~activable~~ segments are formed by providing electrodes 122,123 ~~66 on either~~ to each side of a ~~the~~ channel 124, as a result of which the refractive index of ~~the~~ material 126 located ~~68~~ between the ~~said~~ electrodes will vary upon application of a voltage. As FIGS. 10 and 11 ~~the~~

~~figure~~ diagrammatically indicate, ~~schematically indicates,~~ the lightguides 110, 120 ~~device comprises~~ are each connected to a light source 128 ~~64~~ and a light detector 130 ~~65~~, for example, ~~in this case in the form of~~ a photodiode.

~~[0065]~~ [0064] The lightguides 110, 120 ~~embodiments which are~~ shown in FIGS. 10 and 11 ~~Figures 6a and 6b~~ may ~~can~~ also be used as ~~a~~ spectrophotometers ~~spectrometer~~. When there is no applied electric field, ~~In the non-activated condition of the electrodes 60, 66,~~ incident light will pass through the device substantially unimpeded. When an electric field is applied to ~~In the activated condition of~~ the electrodes, wavelength-dependent light diffusion will occur, and a reduced amount of light will be emitted from the lightguides~~, therefore~~. By measuring the ~~amount of~~ emitted light by means of the detector 130~~65~~ and the value of an applied voltage~~in dependence on the degree of activation of the electrodes~~, the spectral distribution of the incident light can be calculated ~~afterwards~~. The spectrally dependent absorption or fluorescence~~dissolving capacity~~ of the lightguides ~~device thereby~~ depends on the number of segments, the sensitivity to dispersion of the transition between two neighboring ~~neighbouring~~ segments and the number of selected values of the activating parameter ~~quantity~~.

~~[0066]~~ [0065] Referring now to FIGS. 12 and 13, there is illustrated ~~Figure 7 shows an embodiment of~~ a spectrophotometer 140~~spectrometer which cannot be electrically activated~~. As in FIG. 1, there is a carrier 142, a first inclusion layer 144, a core layer 146 and a cladding layer 148. A light source 150 is provided and ~~Besides the known parts, this embodiment contains~~ one or two light detector systems 152~~70~~, for example, in the form of a photodiode array or a ~~(linear)~~ chip including ~~comprising~~ a linear array of photosensitive elements.

~~[0067]~~ [0066] Laterally emitted light 154~~18~~, FIG. 13, from an entering guide mode 156 ~~light wave 10~~ is measured in a locally sensitive manner by means of the light detector systems 152~~said detectors~~. In this manner ~~Thus~~ a light diffusion curve and ~~thus~~ the spectral distribution of the exiting light is determined~~ on-line~~.

~~[0068]~~ [0067] In FIG. 14 a lightguide 160 is shown having a carrier layer 162, a substrate layer 164, a core layer 166 and a parameter sensitive cladding 168 where the parameter sensitive cladding forms two types of segments by virtue of having different widths, namely, wide segments 170 and narrow segments 172. Although the refractive indices of both types of segments 170, 172 are the same, the widths of the two types of segments are geared to each other such that when the amount of measurand is varied, the intensity distribution at each of the transitions between segments will vary inversely thereby resulting in a very sensitive lightguide. It is noted that the lengths of the segments in the direction of light propagation vary, as explained above in relation to the lightguide shown in FIG. 1. ~~Figure 8 is a schematic representation of the embodiment of segments 8 and 8' exhibiting a varying width, seen in plan view A as well as in longitudinal sectional views B and C. The field profiles of the two kinds of segments are substantially the same in this embodiment, but the two types of segments exhibit different refractive index profiles. The illustrated embodiment is an embodiment which comprises an electrode 102, by means of which intensity modulation and/or spectrometer applications can be realised. The embodiment as shown can also be used for sensor applications, however. No upper electrode 102 is present in that case, and an inclusion layer 100 consists of a sensor material. The illustrated longitudinal sections B and C are sectional views along lines 96 and 98, respectively. The widths of the illustrated segments 8 and 8' are geared to each other in such a manner that when a cladding of inclusion material 100 is present and a significant value of an~~

~~activating quantity is applied, for example by means of electrode 102, the mode profiles will be at least substantially identical in both types of segments and will vary in opposite sense upon variation of said quantity. In this manner a highly sensitive device is realised.~~

~~[0069]~~ [0068] FIGS 15 and 16 show ~~Figure 9 shows~~ two ~~cross-sectional views of~~ channel-type-lightguides, a ridge-type channel lightguide 180 in FIG. 15 ~~(A)~~ and a strip-loaded type channel lightguide 182 in FIG. 16~~(B), respectively~~. Each lightguide includes a carrier layer 184, a buffer layer 186, a core layer 188 and a cladding layer 190. The ridge of a ridge-type channel lightguide ~~(A)~~ is formed by a geometric change, such as a local thickening 191~~106~~ in the core layer 188 forming alternating segments 192, 193 ~~lighttransmitting material 4~~. In the ~~a~~ strip-loaded type channel lightguide 182 ~~(B)~~, a cladding shaped as a strip 194 of alternating segments 195, 196 is provided on top of the core layer 188~~no light-transmitting material is present in outside channel 108~~. Both lightguides include ~~embodiments comprise a~~ the second inclusion or cladding layer 190~~100~~.

~~[0070]~~ [0069] FIG. 17 illustrates ~~Figure 10 shows by way of illustration a plan view A, a side view B and a cross-sectional view C of~~ a segmented strip-loaded type channel lightguide 200 which includes a carrier layer 202, a buffer layer 204, a core layer 206 but no ~~does not comprise a~~ second inclusion layer ~~100~~. The lightguide ~~Such a device alternately~~ contains a strip 207 of alternating parameter sensitive ~~activated~~ segments 208 ~~110~~ and desensitized ~~non-activated~~ segments 210 ~~112~~, which together provide a ~~the channel type~~ light transmission channel.

~~[0071]~~ [0070] Referring now to FIG. 18, there is illustrated a lightguide 220 and two types of non-periodic parameter sensitive segments in a cladding layer 222. For example, one type of segment S_1 224 is formed of chemico-optical material and the other type of segment S_2 226 is

formed of electro-optical material. Beneath the cladding layer 222 are a core layer 228, a buffer layer 230 and a silicon wafer 232. The cross-sectioned dimensions of both types of segments are the same and the respective refractive indices are related in that they are identical for relevant values of each measurand.

~~[0072]~~ [0071] At the working point, transmitted light intensity is at a maximum. When the refractive index of the segments 224 changes by virtue of the presence of parameter A, the refractive index of the segments 226 can be changed by altering parameter B, such as an electric field through a control system 234 where the control system is part of a feedback loop that detects light intensity 236 transmitted through the lightguide and seeks to return that intensity to its original maximum value after it is diminished in response to parameter A. This allows parameter A, a chemical concentration, for example, to be measured as a function of the electric field needed to equalize the refractive indices of the two types of segments 224, 226.

~~[0073]~~ [0072] The above specification describes in detail the preferred embodiments of the present invention. Other examples, embodiments, modifications and variations will, under both the literal claim language and the doctrine of equivalents, come within the scope of the invention defined by the appended claims. Further, they will come within the literal language of the claims. Still other alternatives will also be equivalent as will many new technologies. There is no desire or intention here to limit in any way the application of the doctrine of equivalents nor to limit or restrict the scope of the invention.

ABSTRACT OF THE DISCLOSURE

In an integrated optical lightguide device including ~~comprising~~ a light-transmitting core layer, ~~and~~ an inclusion or buffer layer, and an active or cladding layer. The cladding layer ~~an activable element~~ is divided into ~~several individual~~ segments. Groups of different segments ~~thereby~~ exhibit ~~mutually~~ different refractive indices, ~~index profiles, material~~ light intensity profiles or ~~mutually~~ different degrees of sensitivity ~~activability as regards the refractive index profile,~~ which have been effected by different~~, suitable~~ methods. Thus, repeated adjustable or controllable transmission has resulted in an extremely sensitive waveguide system~~, for example~~ for a sensor, a modulator, or a spectrophotometer ~~and the like~~.